PUERTO RICO EXPERIMENT STATION
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

CIRCULAR No. 24

DERRIS CULTURE IN PUERTO RICO

By

RUFUS H. MOORE
Associate Plant Physiologist

Issued September 1943

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
OFFICE OF EXPERIMENT STATIONS

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[1] In cooperation with the Government of Puerto Rico.

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By Rufus H. Moore, *associate plant physiologist* [1]

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INTRODUCTION

Derris elliptica (Roxb.) Benth., a tropical leguminous plant, was the source of about one-half of the United States' supply of rotenone root before the Japanese occupation of the derris-growing countries of the southwest Pacific. *Lonchocarpus* spp. (commonly called cube or timbo), indigenous to tropical South America, provided the rest of the requirements for this vitally important insecticide. The inability of tropical America to supply lonchocarpus root in sufficient quantities for our present needs has stimulated the culture of derris in that region.

Derris was under observation and test in Puerto Rico for several years prior to the present emergency. Two varieties, Sarawak Creeping and Changi No. 3, were introduced in 1931 by the Agricultural Experiment Station of the University of Puerto Rico at Rio Piedras. By mutual agreement between the University station and the Experiment Station of the United States Department of Agriculture at Mayaguez, the study of derris was assumed by the Federal station in 1935.

This circular reviews experience in derris culture in Puerto Rico and includes some reference to cultural methods in the Far East. The relatively high wage of common labor prevents extensive planting of this crop in Puerto Rico. However, the experience gained from growing derris in Puerto Rico can be utilized advantageously in favorable regions of Central and South America and the Antilles.

[1] Chemical analyses reported herein were made by Merriam A. Jones, associate chemist.

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VARIETIES AND THEIR CLIMATIC ADAPTATION

After more than a decade of testing and selection of wild derris in the Far East, two varieties of *Derris elliptica*, namely, Sarawak Creeping and Changi No. 3, were found to be superior to all other selections. As there is a much larger supply of Sarawak Creeping than of Changi No. 3 in Puerto Rico, the former variety was used in all field experiments reviewed in this publication. From the beginning of experimental work in Puerto Rico, the Sarawak Creeping variety has proved to be remarkably well adapted to local conditions. It has grown luxuriantly, shown adaptability to a rather wide range of soil and climatic conditions, and been free from serious insect pests and plant diseases. This and Changi No. 3 have responded differently near the close of the dry season at Mayaguez. At that time Sarawak Creeping has remained leafy while Changi No. 3 has become entirely leafless for a brief period. Representative leaves of these two varieties are illustrated in figure 1.

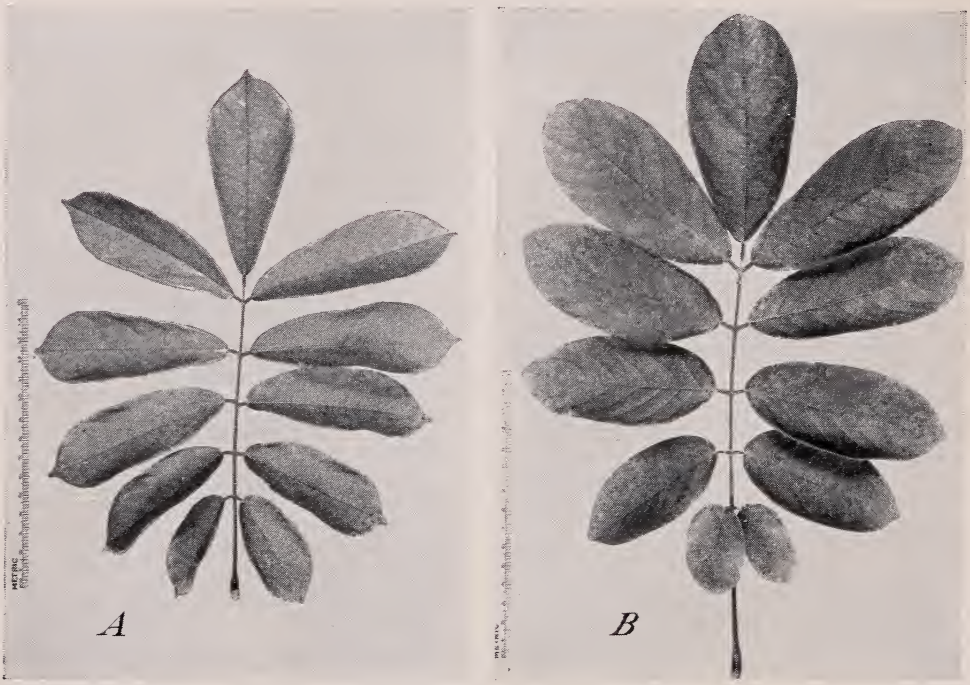

FIGURE 1.—Representative mature leaves of two varieties of *Derris elliptica: A*, Sarawak Creeping, characterized by a slender point at the tip of each leaflet and a bright red pigment in the young leaves; *B*, Changi No. 3, characterized by leaflet tips bluntly pointed to rounded and little red pigment in the young leaves.

Derris ordinarily requires a mean annual rainfall of 80 inches or more. Should precipitation be less than 80 inches, supplementary irrigation may be necessary to develop roots of maximum quality. Distribution of moisture over the year is as important as total annual precipitation since intensely dry periods of longer than 4 months are unfavorable.

Derris grows well at low elevations, but reports vary as to favorable upper limits. Growing derris at more than 2,300 feet above sea level in the Netherlands East Indies is considered probably not an

economical practice (*2*)[2], but the crop is reported to flourish at 4,750 feet in Malaya (*1*). In Puerto Rico, derris grew as well at 1,400 feet as at sea level, but its rate of development during the first year of growth was noticeably slower at 2,400 feet.

SOIL REQUIREMENTS

Since derris is a root crop, soil texture is of primary importance (*11*). Soils ranging from fine sandy loams to sandy clay loams are preferred, because the roots can be dug with the least manual labor, and soil particles adhering to the roots fall away readily when exposed to the drying action of air and sun. In addition, such loams favor the development of a greater proportion of small roots than do most soils high in clay. Soils high in sand dry out too quickly and allow excessively deep root penetration. In heavy soils much labor is expended in breaking clods to secure all roots of commercial size, and the roots themselves must be washed before drying. Certain clay soils, however, are characterized by a crumb structure that facilitates root removal, and hence such soils can be used when their other characteristics are favorable.

Although well-drained soils are ordinarily recommended, it has been observed that derris grows remarkably well on poorly drained land in Puerto Rico. In one planting on a heavy black soil, the average depth to the water table was 15 inches during the height of the rainy season, and occasional downpours temporarily flooded the field; nevertheless, the plants grew well and produced a yield of roots comparable with that obtained from better-drained soils (*14*). On the other hand, there was some indication that poor drainage might have been responsible for a lower rotenone content of the roots. It has been observed also that roots harvested from heavy-textured, poorly drained soils have a noticeable superficial blackening instead of the light-brown color characteristic of roots harvested from better-drained areas, and that this blackening was associated with lowered rotenone content.

To obviate erosion, derris as a root crop should be planted on flat or gently sloping land. Erosion of slopes is likely to be most serious during the first few months after planting and again just following harvest. Usually 5 months or more elapse before derris forms an erosion-resistant tangle of stems and leaves. From the time this protective cover is complete until harvest, erosion is practically nil. For example, scarcely any erosion occurred near Cidra, Puerto Rico, on Cialitos clay (characterized by a fine-crumb structure in the surface soil) with slopes of 9 to 15 percent. Harvest loosens the soil thoroughly to such a depth that torrential rains would cause considerable erosion. However, if the roots were harvested toward the close of the rainy season and the field immediately replanted, the loss of surface soil from sloping land would be minimized.

Areas with deep surface soils free of rocks are preferable for derris, inasmuch as the roots should be loosened to a depth of at least 16 inches at harvesttime. Fields having shallow surface soils or thin soils underlain by rocky strata are undesirable.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 16.

ROOTED VS. UNROOTED CUTTINGS

In commercial practice derris is propagated exclusively by cuttings of any mature stems the size of a pencil (five-sixteenths of an inch) or more in diameter (*2*, *9*). If an ample supply of propagating material is available, cuttings 12 inches long are used, but when the supply is limited 9-inch cuttings are recommended for stems of commercial diameter. Stems thinner than five-sixteenths of an inch should always be made into 12-inch cuttings. No special advantage is gained from preparing cuttings with a specific number of nodes, such as two, so long as each cutting has at least one node more than 1 inch from either end.

In the Far East some derris growers plant fresh cuttings directly at field spacing, a practice which necessitates a large amount of careful weeding until the cuttings become established as well as the filling of vacancies where cuttings fail to grow. Other growers in that part of the world root their cuttings in shaded propagation beds, in pots made from bamboo, or in baskets—practices that may be advantageously employed when the propagation of an especially valuable clone is of primary importance. In Puerto Rico it has been found practicable to root the cuttings in unshaded nurseries before transplanting them to the field.

NURSERY PRACTICE

After having tried several types of nursery practice, this experiment station has adopted the following simplified method: The nursery area is plowed and disked. A lister plow and field hoes are used to make beds consisting of ridges 8 inches high by 18 inches wide and spaced 4 feet from center to center. The ridges are opened transversely with a hoe and the cuttings placed at an angle of about 45° from the horizontal and covered with soil as shown in figure 2. Placing the cuttings on a slant decreases the depth to which one must dig to plant them in the nursery and later to remove them for transplanting to the field. Covering all except the tips minimizes loss by drying and encourages root development near the bases of the new shoots that sprout from the cuttings.

Friable clay or clay loam soils erode less rapidly than do sandy soils and are therefore more satisfactory for derris nurseries. The pounding of torrential rains washes sandy soils away from the upper ends of the cuttings, exposes them to drying, and necessitates frequent repair of the nursery banks until the cuttings become established. Friable clay or clay loam soils retain enough moisture to minimize the loss of unrooted cuttings during brief dry periods, while the surface of sandy soils becomes so hot and dry that the leafless new shoots are burned as they emerge. If sandy soils must be used for nurseries, the damage to emerging shoots can be obviated by light shading or considerably reduced by a thin mulch of cut grass. Compact clay soils are unfavorable to root development.

Cuttings of commercial size should be allowed to remain in the nursery for a period of at least 6 weeks. A minimum percentage of loss will be sustained at the time of transplanting if the cuttings are allowed to remain in the nursery 3 months or more. Cuttings thinner than a pencil require 4 months or more in the nursery.

Nurseries must be weeded by hand. Competition with weeds is particularly serious during the rooting stage, but less frequent weeding is required after the cuttings have become established.

FIGURE 2.—Method of planting field nurseries. In the foreground is a nursery bed with a row of eight cuttings ready to be covered with loose soil. Rows are spaced 6 inches apart along the bed. Note that only the tips of the cuttings are exposed in the rows already planted. Rows of nursery beds in which cuttings have become fully established are shown on the terrace in the background.

TRANSPLANTING AND FERTILIZERS

By the time derris cuttings are well rooted, many of them have developed vines several feet long. Because the vines are often inter-

twined, they are cut back with a machete to stumps about 6 inches long to facilitate removing the plants from the nursery. Any leaves or branches remaining on the vine stumps are pruned away as soon as the cuttings have been dug. If the cuttings are not to be planted for a day or more after digging, they are tied in bundles and completely immersed in a mud bath having the consistency of thick cream to prevent excessive drying. Bundles prepared in this manner are kept in the shade and protected from sunlight and wind by covering with grass or with the fresh vines and leaves removed from the nursery.

The field to be planted should be plowed and disked to good tilth. In Puerto Rico a lister or an ordinary fixed plow is used to open 4-inch planting furrows 3 feet apart. The original cutting and its roots are laid flat on the bottom of the furrow and, if no fertilizer is to be applied, the furrow is then filled with soil, leaving the top of the 6-inch vine stump projecting about 2 inches above the surface. If fertilizer is to be used, about 2 inches of soil is first firmed over the rooted cutting; the fertilizer is then scattered on top and covered with the remaining loose soil, as shown in figure 3.

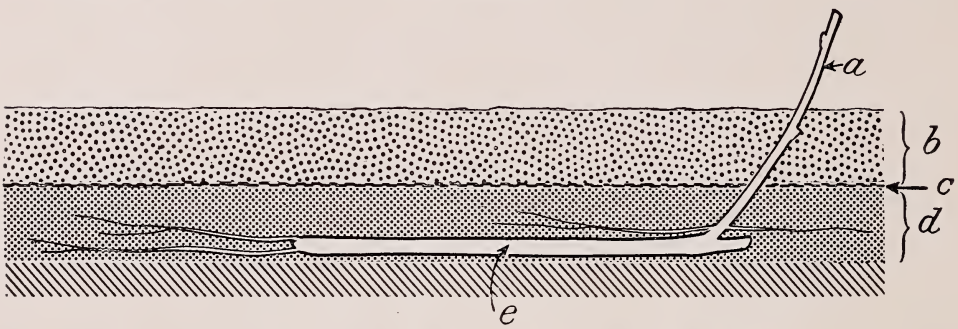

FIGURE 3.—Method of planting rooted derris cuttings in the field: *a*, Vine stump left on cutting; *b*, loose soil covering fertilizer; *c*, fertilizer; *d*, soil firmed over rooted cutting; *e*, rooted cutting.

Fertilizer is applied in the manner described only when the cuttings are planted during the rainy season. Should they be planted near the beginning of the dry season it is advisable to fill the furrows with soil and wait until the next rainy season is well started before applying fertilizer. Then the fertilizer is scattered along the rows of plants and covered lightly, the soil cover forming a slight ridge along each row. If fertilizer is applied to a newly planted field near the close of a rainy season, enough rain may fall to dissolve the soluble constituents of the fertilizer and carry them down into the soil about the roots where they will later become concentrated when the lack of rain dries the top 4 to 5 inches of soil. This will induce a physiological drought that will kill many plants which otherwise would survive the dry season.

Although no experiments have been conducted to prove that shallow placement of fertilizer is efficient, the growth habit of the plant indicates that this method of application results in no loss of the less-soluble constituents, particularly superphosphate. After the plants have become well established they form a dense interlacing mat which permits roots to develop in the superficial layers of the soil.

No comprehensive study of the fertilizer requirements of derris has been reported from the Far East (*5*) or has been undertaken in Puerto Rico. It has been found locally, however, that derris does not respond to heavy applications of ammonium sulfate (*13*) to the marked degree that nonleguminous tropical crops do, but that it develops an abundance of nitrogen-fixing nodules on the roots. The potassium and phosphorus requirements of derris appear to be high by comparison with its nitrogen requirements under field conditions (*2*, *9*).

FIELD SPACING

In the Far East derris is commonly planted at field spacings of ⅔ by ⅔ meter or 1 by 1 meter, the latter spacing being the one recommended. In the Dutch East Indies an increase in the spacing from 1 by 1 meter to 1½ by 1½ meters decreased the yield of roots from 1,530 to 1,048 kilograms per hectare when the vines were allowed to run over the ground and the plants were dug 22 months after planting (*9*).

An experiment near Caguas, Puerto Rico, showed that spacing had no measurable influence on yield of roots with a spacing up to 3 by 3½ feet and a growth period of 26 months. With 20 replications for each spacing, unrooted cuttings, placed 1, 2, and 3 feet apart in rows 3½ feet apart, yielded 900, 920, and 885 pounds of air-dry roots per acre containing 6.5, 6.3, and 6.3 percent of rotenone, respectively.[3] The closer spacings were advantageous in that they produced a complete ground cover more quickly than the wide spacing and hence reduced the cost of weeding.

DIAMETER OF CUTTING

The diameter of the cuttings used to plant a field has some bearing on the yield of roots. This is shown in table 1, which gives data from an experiment, conducted at Mayaguez, in which plants were spaced 2 by 3 feet. The trend, though definite, was not statistically significant, owing to the prolonged growth period. Based on percentage of rotenone and total extractives, the superior quality of the roots from medium and small cuttings compared with that of roots from large cuttings was highly significant.

TABLE 1.—*Yield and quality of roots of Derris elliptica var. Sarawak Creeping from cuttings of 3 ranges of diameter 31 months after planting in the field*

Diameter of cuttings (millimeters) [1]	Air-dry roots per acre	Rotenone	Total extractives
	Pounds	*Percent*	*Percent*
5 to 8	1,010	5.3	16.0
8 to 15	1,094	5.3	15.8
15 to 35	1,117	4.6	13.9

[1] 1 inch equals 25.4 millimeters.

TRELLISING VS. TRAILING CULTURE

In the Far East, trellising is a common practice on small farms but is rarely employed on estates on which derris is often used as a catch

[3] One kilogram per hectare equals 0.892 pound per acre.

crop between young rubber trees. Slender 9-foot poles placed near the plants are stabilized by trellising two rows simultaneously. This is done by lashing together two poles from one row with one pole from the adjacent row at about the 5-foot level to form a tripod, or by tying together poles that are opposite each other in the two rows and stabilizing these pairs with a horizontal stringer at the 5-foot level of union.

In Puerto Rico the trellises in use for derris consist of living poles as uprights, with cross stringers of dry bamboo or galvanized-iron wire. The uprights are 6-foot cuttings of dwarf bucare (*Erythrina berteroana* Urban) or madre de cacao (*Glyricidia sepium* (Jacq.) Steud.) that are pointed and worked 18 inches into the soil, where they root and remain alive indefinitely. The stringers are attached to the uprights at 1½-foot intervals.

Experimentation at Mayaguez (*14*) has shown that the yield of air-dry roots was increased three-fourths and the concentration of rotenone lowered one-eighth when derris was trellised rather than allowed to trail over the ground. Whether or not trellising would increase the net returns from the crop has not been determined experimentally. A considerable quantity of trellising materials would be needed for large-scale plantings. The additional costs, particularly for labor, involved in the installation and removal of trellises and in the increased number of weedings might offset the greater returns from increased root production. Also to be considered is the fact that, when trellised, derris loses most of its value as an erosion-resistant crop.

It is highly desirable to trellis derris if the primary object of planting is to secure the most rapid possible increase of cutting material. Derris grown on trellises produced 300 percent more usable cuttings than did plants allowed to trail over the ground.

RELATION OF LIGHT TO YIELD

Several experiments have indicated that the yields of both roots and cuttings depend to a great extent upon the total exposure of active leaves to sunlight. The marked difference in yields cited in the two preceding paragraphs supports this view, for throughout most of the growth period a much greater total of leaf area of trellised plants than of trailing plants was exposed to sunlight. When only trailing culture was used in an experiment the plants intercepted a maximum amount of light as soon as the vines completely covered the soil; so only such advantages as might result from differences in rates of coverage would affect the final results.

In the spacing experiment, for example, plants separated by only 1 or 2 feet along the row had completely covered the ground and hence were intercepting the maximum amount of sunlight after 5 to 6 months' growth. Plants in the 3-foot spacing required about 2 additional months to form a closed mat of vines and leaves. Competition of plants for sunlight was the same regardless of spacing from about the eighth to the twenty-sixth month, so that during this later period any initial advantage of close spacing in relation to light was dissipated.

In the size-of-cutting experiment, plats in which cuttings of large and medium diameter had been planted were more quickly covered by vines than were plats in which cuttings of small diameter were used.

Coverage of all plats had been completed before the end of the first year of growth. Table 1 shows the slight differences in yield of roots when the plants were harvested at the end of 31 months. Any effect of the rate of coverage during the first 12 months was partly obscured by uniform exposure to light during the succeeding 19 months.

NOTES ON PHYSIOLOGY OF ROTENONE

Certain physiological studies have yielded results of interest to the grower of rotenone crops. It has been found, for instance, that regular and prolonged defoliation of derris plants almost completely exhausted the carbohydrate reserves but did not alter the rotenone content per given volume of fresh root (*13*). Hence, derris cannot use up the rotenone stored in its roots as sugarcane can draw upon the sucrose stored in its stems.

The fact that rotenone stored in the roots of derris is thus not translocated and utilized by the plant has two applications: (1) The derris plant will not remove rotenone from the roots when the tops undergo a flush of growth, which permits of harvesting at any season of the year without loss of rotenone; (2) at harvest a considerable interval between the removal of the vines and the plowing out of the roots will not result in lowering the percentage of rotenone in the crop.

Both observation and experiment have shown that periods of vigorous growth are essential to the formation of rotenone in derris roots (*13*, *14*). In a greenhouse experiment (*15*), plants that were forced to grow rapidly by the application of an abundance of fertilizer and water, with some reduction of light, stored 3.9 times as much rotenone in their roots as plants that were retarded. A similar trend existed between roots harvested near Caguas from a fertile field with adequate rainfall as compared with those dug near Aibonito from an infertile field with deficient rainfall and no supplementary irrigation.

WEEDS

The weed problem changes with the age of the derris planting. In nontrellised fields mechanical cultivation helps to keep weeds controlled for a few months after planting, but to avoid damage to the tender young stems such cultivation should be discontinued when the vines begin vigorous growth. Some hand and hoe weeding is necessary between the plants from the time the cuttings are transplanted and until the tops begin to close in. As soon as the derris stems become so numerous that they will be injured by hoeing, weeds must be removed entirely by hand. Nutgrass (*Cyperus rotundus* L.), a particularly obnoxious sedge in cultivated fields, is bothersome in the first few weeding operations. Since this weed does not have the capacity to extend its leaves above the canopy of derris, it is partly killed out during the 2-year period in which the crop is usually allowed to grow. Certain other herbaceous weeds, troublesome in new fields, are brought under control as the plants develop.

Bermuda grass (*Cynodon dactylon* (L.) Pers.) and cojitre (*Commelina elegans* H. B. K.) are problem weeds throughout the growth of the crop; even after derris has formed its characteristic mat they continue as pests that overtop the field. They are difficult to eradicate

because each broken stem fragment left in the field can grow into a new plant. Cojitre can withstand prolonged drying without being killed. Several herbaceous vines, such as pica-pica (*Stizolobium purpureum* (Wight) Piper), spread over the top of derris in all stages of growth, but die quickly when uprooted. The vigorous malojillo grass (*Panicum barbinode* Trin.) offers serious competition by growing 3 to 4 feet above derris and is difficult to eradicate in that some of the stems, growing appressed to the soil beneath the tangled derris mat, root at the nodes.

HARVESTING AND YIELDS

The age at which derris should be harvested is determined by yield per acre and quality of roots. Yield increases with age, but quality gradually decreases after the second year (*7*) for reasons discussed under Rotenone Content and Sampling of Roots. Generally a 2-year growth period is advised, but a cycle of 18 months has been proposed. Local climatic and soil conditions, variety, field spacing, and efficient utilization of labor should influence the choice of length of the crop cycle.

Harvesting derris, which consists of clearing the tops from the field and removing the roots from the soil, and the preparation and planting of nurseries are carried on simultaneously.

Clearing the tops from a field of nontrellised derris is made difficult by the frequency with which old vines on the bottom of the tangled mat become rooted to the soil. Many dead leaves, trapped in this lower layer and protected by the green leafy upper layer of the mat, provide conditions that favor prolific rooting. The thickest stems, in contact with the soil, must be carefully severed from their roots to incur minimum damage to the cutting material they will provide.

The tops are removed in the following manner: Machetes are used to cut the mat of tops into strips three rows wide which are rolled up as illustrated in figure 4. A strip 18 to 20 feet long is usually sufficient to make a roll that can be conveniently removed from the field. The thickest stems are exposed on the surface of the roll and, for ordinary commercial practice, may be removed for cutting material as the roll advances. Excessive drying of this cutting material can be prevented conveniently by covering it with pieces of the mat from which vines of commercial size have been removed.

Many of the smaller vines, however, can be used. If an increase in cutting material is of primary interest it is best to transfer the intact rolls to a shady place, spread them out with the old vines uppermost, and select all mature stems. The planting of nurseries can be expedited by arranging the selected vines in small bundles with their basal ends together, tying the bundles at intervals of 6 inches with unusable vines, and sawing them into packets of cuttings 12 inches long. Inasmuch as the vines are arranged with their basal ends together, the packets prepared from them are ready for immediate planting without the necessity of examining each cutting before placing it in the nursery bed. These packets can be protected with the dead leaves that shatter from the unused portion of the derris mat removed from the field. Cuttings should be planted within 10 days or they will usually become dry or begin to sprout. The method of placing them in nurseries has already been described.

Removal of roots from the soil completes a crop cycle. In the Far East the roots are grubbed out with special hoes to a depth of 3 feet. Estates ordinarily employ the short-period cropping system (*2*, *9*) in which all roots are removed when a field is harvested. The small farmer, who frequently trellises his plants, follows the so-called permanent or Changi system of culture, which involves leaving the tops in place and removing all roots save those which penetrate deeply into the soil directly under the plant. This root-pruning practice makes it possible to secure several harvests from the same plants.

FIGURE 4.—A method of clearing derris vines from the field. Three men with hooked poles exert a pull on the roll to facilitate the work of 2 men with machetes who cut loose the vines as the roll advances. One of the two men with machetes does not appear in this photograph.

It is highly desirable to clean the field before harvesting the roots of trailing plants, inasmuch as pieces of stems and other foreign material add to the labor of cleaning the roots for market. In Puerto Rico the roots are cut with a plow to a depth of 16 inches, and are removed from the loosened soil with potato forks. Since a root-distribution study in Puerto Rico (*13*) showed that 81 percent of all roots were in the upper 16 inches of soil, no effort has been made in field experiments to recover roots beyond this depth because of the extra labor involved. A small caterpillar tractor has sufficient power to open a 16-inch furrow in a single operation, but the use of oxen necessitates 2 cuts in the same vertical plane. The first cut usually reaches a depth of 8 to 9 inches and the second a depth of 15 to 16 inches, as shown in figure 5. Roots should be removed from the loosened soil of the first cut before the second cut is started.

The roots should be freed of all foreign material such as parent cuttings, pieces of derris vines, and roots of weeds. The stems of

FIGURE 5.—Harvesting derris roots with an ox-drawn plow and potato forks. Men with potato forks are about to remove roots from the second cut made by the plow.

the cuttings that were used to plant a field, locally known as parent cuttings, might easily be mistaken for roots at harvesttime because

they are left in the soil when the tops which developed from them are cleared away. Thickened by growth, the parent cuttings constitute a considerable part of the plant tissues loosened by the plow. These should not be included with the roots because they have only about 0.5 percent of rotenone and are excellent propagating material.

Derris harvested from experimental plats in Puerto Rico at 25 to 27 months of age has yielded from 885 to 1,738 pounds of air-dry roots per acre when the trailing system of culture was used, and 3,040 pounds when the plants were trellised. These yields compare favorably with those reported from the Far East (*9*).

DRYING AND MARKETING ROOTS

If the soil is of such a character that most of it does not shatter readily from the roots in the early stages of drying it is advisable to wash the roots before placing them to dry, as dirty roots are not considered first-class by the trade. Roots with intact bark can be dried in direct sunlight with no destruction of rotenone [4] and should be spread out until the thickest of them are snap-dry. Under favorable weather conditions roots may be dried out of doors in 7 to 15 days, but drying in well-ventilated sheds requires about 3 weeks. During the drying process ventilation should be ample to prevent damage by molds. Some growers in the Far East prefer to cut the fresh roots into pieces 1½ to 2 inches long, and when dry to ship them in bags as "chips."

Imports of rotenone roots into the United States have increased rapidly during the past 5 years, reaching a total of 8 million pounds in 1941. The upward trend in demand may be expected to continue as entomologists extend the use of rotenone insecticides. Market quotations are based on roots having 5 percent of rotenone and 8 to 12 percent of moisture. Premiums are paid for roots with more than 5 percent of rotenone and deductions are made for those of lower quality. Roots containing less than 3 percent of rotenone are usually not accepted. Some importers also require a minimum ratio of 1 to 3 between rotenone and total extractives.

ROTENONE CONTENT AND SAMPLING OF ROOTS

Reports on the variation of rotenone content of derris in relation to root diameter have led to some confusion, owing largely to variation in methods of sorting the roots. Investigations at this experiment station have shown that roots less than one-thirty-second of an inch in diameter are relatively low in rotenone, and that roots increase rapidly in rotenone content with increase in diameter up to about one-fourth of an inch and then decrease in rotenone as their diameter continues to increase. The apparent decline in percentage of rotenone, as roots larger than about one-fourth of an inch continue to thicken, is not due to loss of rotenone but to an increasing rate of starch accumulation. It has also been shown that roots of the same diameter taken from the same set of plants may vary more than 100 percent in rotenone content (*13*).

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[4] JONES, M. A. [EFFECT OF METHOD OF DRYING ON ROTENONE CONTENT OF ROOTS OF DERRIS ELLIPTICA.] 1942. [Unpublished.]

Variation in the rotenone content of roots emphasizes the need of careful sampling to secure as nearly a representative group of roots as possible for chemical analysis. A modification of the method of sampling used in the Far East (*6*) is recommended. Small, representative bunches of roots, equivalent to not less than one-half of 1 percent of the shipment, are removed at frequent and regular intervals and piled together as dry roots are being baled. This rough sample is then cut into 3-inch lengths, thoroughly mixed, and spread out in the form of a square. Roots in opposite quarters of the square are discarded, and those in the other two quarters are repeatedly put through this process of mixing, spreading, and sampling until reduced to about 5 pounds. The original method prescribed cutting roots into 6-inch pieces and reducing them to a 1-pound sample. The above modification seems more advantageous, since 3-inch root pieces can be mixed more easily and thoroughly than 6-inch pieces and importers sometimes require a 5-pound sample. The roots discarded from the rough sample may be packed in the middle of the last bale.

LABOR REQUIREMENTS

Though derris has been grown commercially in the Far East for more than a decade, no information on the number of man-days required per acre to produce a crop is available from that part of the world. Costs of production on record (*11*) are of little value, because the field operations were often sublet to contractors.[5]

An accurate record was kept in Puerto Rico of the labor involved in growing 2.3 acres of derris in the spacing experiment already described. An average of 423 man-days per acre was needed to complete one crop cycle—a labor requirement that must be considered high, inasmuch as the area was not planted on a strictly commercial basis and the laborers had no previous experience with this crop. Weeding costs were 19 percent of the outlay for labor and could be lessened somewhat by using duckfoot cultivators instead of hoes in new fields until the vines become too long. Harvesting used 64 percent of the labor—an expense item that could be considerably reduced by the development of adequate machinery. Establishing the nurseries involved 10 percent of all labor. Preparing the field, planting, supplying vacancies, applying fertilizer, and baling roots accounted for the remaining 7 percent of the total man-days utilized.

INSECTS AND DISEASES

A number of insect pests and plant diseases have been reported as attacking derris (*3*, *4*, *17*). Dried roots of both derris in Malaya (*10*) and cube in South America (*8*) are attacked by larvae and adults of a beetle, *Dinoderus bifoveolatus* Woll. Of the other beetles that attack dry derris root in Malaya, one species, *D. minutus* F., commonly infesting dried bamboo, has not yet been found infesting stored derris root in Puerto Rico. Such damage can be prevented by grinding the roots as soon as dry and packing the powder immediately, or by cutting the fresh roots into chips which are dried and packed with the least possible delay (*9*).

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[5] SIEVERS, A. F. THE PRODUCTION AND MARKETING OF DERRIS ROOT. U. S. Dept. Agr. (Bur. Plant Indus.), [18] pp. [1940. Processed.]

Insect pests have caused insignificant injury to derris plants growing in Puerto Rico. A leaf-webber, *Hedylepta indicata* (F.), and the leaf-tiers *Proteides mercurius pedro* (Dewitz) and *Acolastus amyntas* (F.)

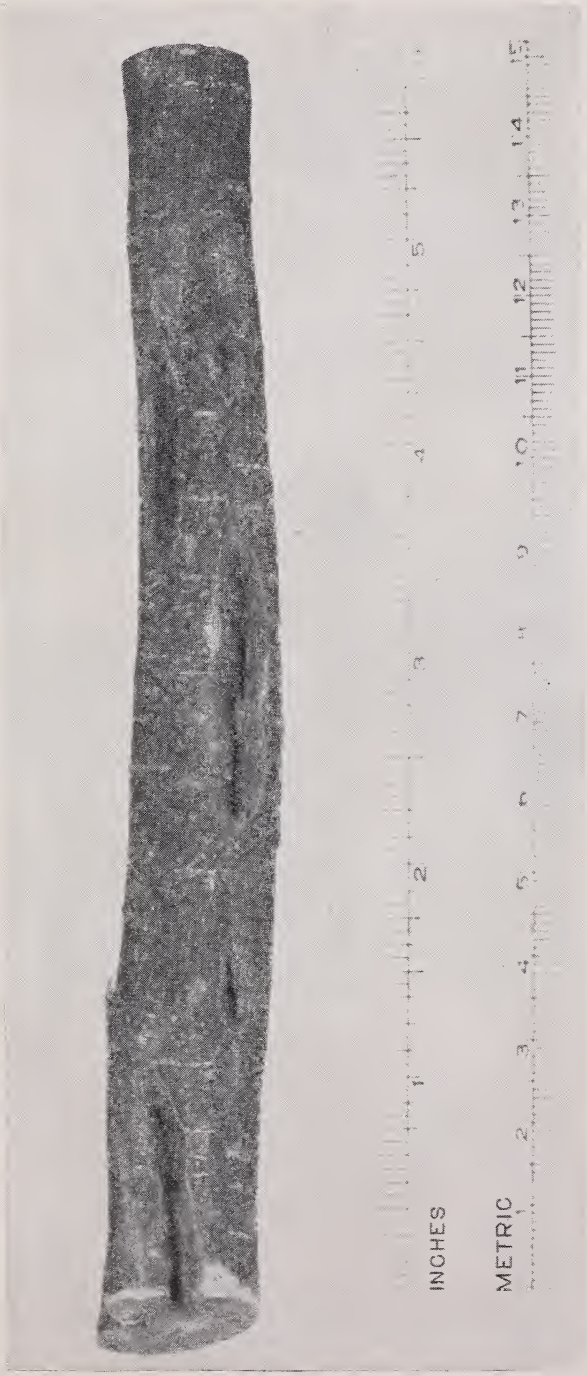

FIGURE 6.—A derris root showing exceptionally severe injury caused by soil-inhabiting larvae similar to those attacking the roots of sugarcane, *Diaprepes* sp. Ordinarily this type of injury is insignificant.

have occasionally damaged the leaves (*12*, *16*). On rare occasions the larvae of a few other common leaf feeding insects have caused minor defoliation of young leaves (*16*). Growing roots are occasionally

injured by weevil larvae, *Diaprepes* sp. probably *abbreviatus* L. or *capsicalis Marshall*,[6] that chew into the surface as shown in figure 6.

Although several plant diseases have been reported on derris in the Far East, none of any consequence has been observed in any of the plantings made to date in Puerto Rico. During the drier part of the year the younger leaves develop brown spots that are apparently physiological in origin since they fail to develop on the growth flush that follows spring rains.

SUMMARY

The growing of *Derris elliptica* in Puerto Rico is described and discussed with some reference to cultural methods used in the Far East.

The Sarawak Creeping and Changi No. 3 varieties are commercially superior to other selections of derris that have been tested.

Unshaded nurseries, described in detail, have proved a practical means of rooting cuttings on a large scale. The use of rooted cuttings reduces the amount of weeding required and assures a more uniform stand of plants in the field.

Simple methods of transplanting rooted cuttings and applying fertilizer are presented. Little is known of the fertilizer requirements of derris.

Propagating material of commercial size is used most efficiently at a field spacing of 3 by 3 feet, but weeding costs are reduced by closer spacing. Large cuttings produce plants that cover the soil more quickly and yield more roots per acre than small cuttings.

Trellising the vines increased the yield of roots 75 percent and the number of cuttings 300 percent over those not trellised, but the labor requirement for trellising may be correspondingly increased.

The yield of roots is directly correlated with the total amount of light to which the plants are exposed during growth. Rotenone deposition is favored by flushes of growth; but rotenone, once stored in the roots, remains there.

Since 81 percent of the roots are found in the upper 16 inches of soil, harvesting below this level is not economical in countries with a relatively high wage scale.

Labor for a nontrellised crop was distributed as follows: Nurseries, 10 percent; weeding, 19 percent; harvesting, 64 percent; and miscellaneous, 7 percent.

Insects and diseases attacking derris in Puerto Rico have caused negligible damage.

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[6] As determined by W. H. Anderson, Bureau of Entomology and Plant Quarantine.

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